

CLAIMS

WE CLAIM:

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1. A process for creating a broadly tunable Distributed Bragg Reflector (DBR) structure with a low spontaneous recombination rate at operating temperatures comprising the steps of:
 - 6 creating a first cladding layer of a first conductivity type;
 - 9 creating an optical waveguide disposed on top of said first cladding layer comprising the steps of creating one or more hole confinement regions and creating one or more electron confinement regions wherein energy barriers of greater than the thermal energy, kT , separate adjacent confinement regions;
 - 12 creating a second cladding layer of a second conductivity type disposed on top of said optical waveguide.
- 15 2. The process of claim 1 further comprising the step of creating a grating layer.
- 18 3. The process of claim 1 wherein:
 - a conduction band energy barrier greater than the thermal energy, kT , is created by establishing an effective conduction band offset between adjacent confinement regions;
 - 21 a valence band energy barrier greater than the thermal energy, kT , is created by establishing an effective valence band offset between adjacent confinement regions;

the band gap of said first cladding layer and the band gap of said second cladding layer are greater than the effective band gaps of said hole confinement regions;

24 the band gap of said first cladding layer and the band gap of said second cladding layer are greater than the effective band gaps of said electron confinement regions;

27 a first cladding layer conduction band energy barrier greater than the thermal energy, kT , is created by establishing an effective conduction band offset between the conduction band of said first cladding layer and the conduction band of the adjacent confinement layer;

30 a second cladding layer conduction band energy barrier greater than the thermal energy, kT , is created by establishing an effective conduction band offset between the conduction band of said second cladding layer and the conduction band of the adjacent confinement layer;

33 a first cladding layer valence band energy barrier greater than the thermal energy, kT , is created by establishing an effective valence band offset between the valence band of said first cladding layer and the valence band of the adjacent confinement layer; and

36 a second cladding layer valence band energy barrier greater than the thermal energy, kT , is created by establishing an effective valence band offset between the valence band of said second cladding layer and the valence band of the adjacent confinement layer

4. The process of claim 1 wherein said first cladding layer comprises an n-type

45 cladding layer and said second cladding layer comprises a p-type cladding layer.

5. The process of claim 1 wherein said first cladding layer comprises a p-type

cladding layer and said second cladding layer comprises an n-type cladding layer.

48 6. The process of claim 3 wherein a valence band energy barrier greater than twice

the thermal energy, $2kT$, is created by establishing an effective valence band offset

between adjacent confinement regions.

51 7. The process of claim 3 wherein a conduction band energy barrier greater than

twice the thermal energy, $2kT$, is created by establishing an effective conduction band

offset between adjacent confinement regions.

54 8. The process of claim 3 wherein a cladding conduction band energy barrier equal

to greater than twice the thermal energy, $2kT$, is created by establishing an effective

conduction band offset between the conduction band of said first cladding layer and the

57 conduction band of the adjacent confinement layer.

9. The process of claim 3 wherein a cladding conduction band energy barrier equal

to greater than twice the thermal energy, $2kT$, is created by establishing an effective

60 conduction band offset between the conduction band of said second cladding layer and

the conduction band of an adjacent confinement layer.

10. The process of claim 3 wherein a cladding valence band energy barrier equal to

63 greater than twice the thermal energy, $2kT$, is created by establishing an effective valence

band offset between the valence band of said first cladding layer and the valence band of

the adjacent confinement layer.

66 11. The process of claim 3 wherein a cladding valence band energy barrier equal to
greater than twice the thermal energy, $2kT$, is created by establishing an effective valence
band offset between the valence band of said second cladding layer and the valence band
69 of the adjacent confinement layer.

12. The process of claim 3 wherein the step of creating said broadly tunable DBR
comprises creating one or more graded layers.

72 13. The process of claim 12 wherein said first cladding layer comprises one or more
graded layers.

14. The process of claim 12 wherein said second cladding layer comprises one or
75 more graded layers.

15. The process of claim 12 wherein said optical waveguide comprises one or more
graded layers.

78 16. The process of claim 12 wherein said graded layer varies in composition across
the thickness of said optical waveguide.

17. The process of claim 12 wherein said graded layer varies in energy band structure
81 across the thickness of said DBR.

18. The process of claim 12 wherein said graded layer varies in composition across
the breadth of said DBR.

84 19. The process of claim 12 wherein said graded layer varies in energy band structure
across the breadth of said DBR.

20. The process of claim 3 wherein the thickness of said optical waveguide is selected
87 to support a single optical mode.

21. The process of claim 3 wherein said optical waveguide comprises one electron confinement region and one hole confinement region wherein said electron confinement

92 layer comprises a layer of material of uniform composition and said hole confinement layer comprises a layer of material of uniform composition.

22. The process of claim 3 wherein said optical waveguide comprises one electron

93 confinement region and one hole confinement region wherein said electron confinement

layer comprises a layer of material of uniform energy band structure and said hole confinement layer comprises a layer of material of uniform energy band structure.

96 23. The process of claim 3 wherein adjacent confinement regions comprise layers of

lattice matched materials.

24. The process of claim 23 wherein said electron confinement regions comprise

99 InGaAsP material lattice matched to InP and said hole confinement regions comprise

InGaAlAs material lattice matched to InP.

25. The process of claim 23 wherein said electron confinement regions comprise

102 InGaAsSb material lattice matched to InP and said hole confinement regions comprise

InGaAlAsSb material lattice matched to InP.

26. The process of claim 3 wherein the thickness of said electron confinement regions

105 is greater than the thickness of said hole confinement regions.

27. The process of claim 3 wherein the effective conduction band offset between

adjacent confinement regions is greater than the effective valence band offset between

108 adjacent confinement regions.

28. The process of claim 3 further comprising the step of creating one or more graded

layers disposed between said optical waveguide and said first cladding layer.

111 29. The process of claim 3 further comprising the step of creating one or more graded
layers disposed between said optical waveguide and said second cladding layer.

114 30. The process of claim 3 further comprising the step of creating one or more graded
layers disposed between adjacent confinement regions.

117 31. The process of claim 1 further comprising the step of creating one or more
additional cladding layers.

120 32. The process of claim 1 wherein said energy barriers are created by band gap
tilting wherein:

123 said optical waveguide comprises a layer of graded material wherein the
energy level of the lowest conduction band of said waveguide increases across the
thickness of said waveguide, the energy level of the highest valence band of said
waveguide increases across the thickness of said waveguide and the energy band
gap of said waveguide varies across the thickness of said waveguide;

126 the changes in said energy levels creates an electron confinement region in
said optical waveguide comprising a region wherein said energy level of the
lowest conduction band and the adjacent cladding layer forms a local minimum in
the conduction band;

129 the changes in said energy levels creates a hole confinement region in said
optical waveguide comprising a region wherein said energy level of the highest
valence band and the adjacent cladding layer forms a local maximum in the
valence band;

132 the average band gap of said optical waveguide is greater than or equal to the carrier concentration in said optical waveguide divided by twice the thickness of said optical waveguide.

135 33. The process of claim 32 wherein:

 said optical waveguide comprises one or more layers of material wherein the energy band structure varies across the breadth of said waveguide.

138 34. The process of claim 32 wherein said conduction band and said valence band of said graded layer comprise sloped, stepped or curved profiles across the thickness of said optical waveguide.

141 35. The process of claim 32 wherein the materials composition of said graded layer comprise sloped, stepped or curved profiles across the thickness of said optical waveguide.

144 36. The process of claim 32 wherein said conduction band and said valence band of said graded layer comprise sloped, stepped or curved profiles across the breadth of said optical waveguide.

147 37. The process of claim 32 wherein the materials composition of said graded layer comprise sloped, stepped or curved profiles across the breadth of said optical waveguide.